REMARKS

Applicants thank the Examiner for the very thorough consideration given the present application.

Claims 1-14 are now present in this application. Claims 1, 13 and 14 are independent.

Amendments have been made to the title of the invention and the specification. Claim 1 has been amended. Claims 13 and 14 have been added. Reconsideration of this application, as amended, is respectfully requested.

PRIORITY UNDER 35 U.S.C. §119

Applicants thank the Examiner for acknowledging Applicant's claim for foreign priority under 35 U.S.C. §119, and receipt of the certified priority document.

DRAWINGS

The Applicants thank the Examiner for indicating that the drawings filed on March 8, 2002 have been accepted.

OBJECTION TO THE TITLE OF THE INVENTION

The Examiner objected to the title of the invention. To address this objection, Applicants have amended the title of the invention in accordance with the Examiner's suggestion.

SUBSTITUTE SPECIFICATION

Applicants have submitted herewith a Substitute Specification The Substitute Specification does not contain new matter. A marked-up copy of the original specification showing the matter being added to and deleted from the specification is also submitted herewith. The Examiner is respectfully requested to approve the Substitute Specification.

SPECIFICATION AMENDMENTS

Applicants have amended the specification in order to correct minor typographical errors, and to place the specification in better form.

CLAIM AMENDMENTS

Applicants have amended the claims in order to place the claims in better form. The claim amendments are not being made in response to any statutory requirement for patentability, and have not been narrowed in scope. Instead, the claims have been amended merely to recite the subject matter therein more clearly.

REJECTION UNDER 35 U.S.C. §103

Claims 1 and 5 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,558,996 to Becker and further in view of U.S. Patent No. 3,644,068 to Lepak, referenced by U.S. Patent No. 4,969,808 to Tsukada. This rejection is respectfully traversed.

A complete discussion of the Examiner's rejection is set forth in the Office Action, and is not being repeated here.

While not conceding the appropriateness of the Examiner's rejection, but merely to advance prosecution of the instant application, Applicants respectfully submit that independent claim 1 recites a combination of elements in a roller pump including said pump housing and said reduction gear are integrated into one body and an output shaft of said reduction gear is fixed to said drive shaft of said rotor. Applicants respectfully submit that this combination of elements as set forth in independent claim 1, is not disclosed or made obvious by the prior art of record, including Becker.

The Examiner asserts that Becker (in Fig. 6) teaches a roller pump (5) comprising a housing (12a,14,52,28) having a cylindrical inner surface (62,40,63), and a rotor (120) fixed to a drive shaft (104) placed at the central portion of the pump (5) housing (12a,14,52,28). The Examiner admits that the Becker device differs from the claimed invention in that Becker provides no explicit teaching of a driver driving the drive shaft through a reduction gear.

The Examiner relies on Lepak and Tsukada to supply the deficiencies of Becker.

With respect to Lepak, the Examiner states that Fig. 1 of Lepak teaches a roller pump with a drive shaft (30) driven by a motor (12) via a gear box (14). With respect to Tsukada, the Examiner asserts that Tsukada teaches a roller pump with a motor (21) driven shaft (13) via reduction gears (22). In view of these arrangements, the Examiner asserts that it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Becker device by utilizing a reduction gear box, as taught by Lepak as referenced by Tsukada, in order to match the desired rotor speed given a stock motor. Further, the Examiner asserts that it is obvious that the pump housing (62,40,63) and the reduction gear are integrated into one body, asserting that, they are assembled, fastened, and function as one component and an output shaft (30).

The Examiner's assertion (above) that it is obvious that the pump housing (62,40,63) and the reduction gear are integrated into one body is confusing. Reference numerals (62,40,63) designate features of the device of Becker, which does not have a reduction gear. So then, the Applicants do not follow how it is obvious that the pump housing (62,40,63) and the reduction gear of Becker are integrated into one body.

In this regard, the Applicants also submit that Lepak, relied on by the Examiner to provide a reduction gear box for Becker, cannot supply this

deficiency. Particularly, the gear box 14 of Lepak is not integrated with case means 16, which houses ½ of the pump of Lepak, and end cap 18 which houses the other ½ of the pump of Lepak. In terms of supplying a gear box integrated with a pump, Lepak fails because the casing means 16 of Lepak (pump housing) does not house any gears. Casing means 16 does not even completely house the pump of Lepak. For example, Fig. 3 shows that ½ of the pump is housed in end cap 18 and the other half is housed in casing means 16. Further, end cap 18 is separable from case means 16 in order to provide maintenance for the resilient tube 20 (see Figs. 1, 2 and 3). This is possible because it is a separate body. Therefore, the pump of Lepak itself is not housed in one body in the first instance.

Lepak is also overcome because a "gearbox" 14 is disclosed therein. This is because, a gearbox (by definition) has its own separate casing. Particularly, a gearbox is defined as the shell (metal casing) in which a train of gears is sealed. Clearly then, the gears sealed in gearbox 14 are not integrated into the same body as a pump housing (the 16,18 combination) of Lepak but by definition has a separate casing.

With respect to this point, Tsukada adds nothing more than Lepak. In fact, the pump body 11 of Tsukada and reduction gears 22 of Tsukada are even farther removed from each other than the gearbox 14 of Lepak and the pump housing combination (16,18) of Lepak are removed from each other.

By contrast with Lepak and Tsukada, the Applicants' claims 1 provides for a roller pump comprising a pump housing, wherein the pump housing and the reduction gear are integrated into one body. Applicants therefore respectfully submit that the combination of elements as set forth in independent claim 1 are not disclosed or made obvious by the prior art of record, including Becker, for the reasons explained above.

Claim 5 depends on claim 1, and therefore is patentable for at least the reasons stated with respect to claim 1. Reconsideration and withdrawal of this art grounds of rejection are respectfully requested.

Claims 7 and 11 stand rejected under 35 U.S.C.§103(a) as being unpatentable over Becker, as modified by Lepak referenced by Tsukada, as applied to claims 1 and 5, and in further view of JP60088885A to Ohira et al. (Ohira). This rejection is respectfully traversed.

With regard to claims 7 and 11, Applicants submit that claims 7 and 11 depend from claim 1, which is allowable for the reasons set forth above, and therefore claims 7 and 11 are allowable based on their dependence from claim 1. Allowance of claims 7 and 11 is respectfully requested.

Claims 1 and 3 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Beller et al. (U.S. 20020001527 A1) and further in view of Lepak, referenced by Tsukada. This rejection is respectfully traversed.

The Examiner states that the Beller reference (Beller) differs from the claimed invention in that there is no explicit teaching of a driver driving the

drive shaft through a reduction gear. The Examiner relies on the combination of Lepak and Tsukada to supply the deficiency of Beller.

Lepak and Tsukada (argued above) fail to teach or suggest a roller pump comprising a pump housing, wherein said pump housing and said reduction gear are integrated into one body. Similarly, Beller also fails to teach a combination of elements including this feature. Therefore Beller, in view of Lepak, referenced by Tsukada, cannot render claims 1 and 3 obvious to one of ordinary skill in the art. Accordingly, reconsideration and withdrawal of this art grounds of rejection are respectfully requested.

Claim 9 stand rejected stands rejected under 35 U.S.C. §103(a) as being unpatentable over Beller, as modified by Lepak referenced by Tsukada, as applied to claim 3, and further in view of Ohira.

Claims 2 and 4 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Beller, as modified by Lepak and Tsukada, as applied to claim 1, and in further view of U.S. Patent No. 5,387,088 Knapp et al. (Knapp) and Suzuki et al. (Suzuki).

Claims 2 and 6 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Becker, as modified by Lepak and Tsukada, as applied to claim 1, and in further view of Knapp and Suzuki.

Claim 12 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Becker, as modified by Lepak, Tsukada, Knapp and Suzuki, as applied to claims 2 and 6 and in further view of Ohira.

Claim 8 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Becker, as modified by Lepak, Tsukada, Knapp and Suzuki, as applied to claim 2, and in further view of Ohira.

Claim 10 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Beller, as modified by Lepak referenced by Tsukada, as applied to claim 4, and in further view of Ohira.

These rejections are respectfully traversed.

While not conceding to the appropriateness of the Examiner's rejections, but merely to advance prosecution of the instant application, Applicants respectfully submit that claims 2-12 depend, either directly or indirectly on independent claim 1, which is believed to be allowable, and therefore claims 2-12 are allowable based on their dependence on independent claim 1. Consideration and allowance of claims 2-12 are respectfully requested.

CLAIMS 13 AND 14

Claims 13 and 14 have been added for the Examiner's consideration.

Claim 13 recites a combination of elements in a roller pump, including a part of said inner surface of said pump housing is composed of a semi-circle of which center coincides with a center of said drive shaft, another part of said inter surface is composed of a partial circle of which center is shifted from the center of said drive shaft, and which the length of radius is equal to that of the semi circle. Applicants respectfully submit that this combination of elements

as set forth in claim 13 is neither disclosed, nor suggested by the prior art of record, including Becker.

Becker teaches that door stator (50) and fixed stator member (12A) are so constructed that upon closing they provide a continuous curved inside surface (62) in an otherwise two-dimensional plane, and being a predetermined diameter (here 1.750 inches) for an uninterrupted 180° until a ramp (63) is encountered for both inlet and outlet sections of tubing (270). The ramp (63) is provided to eliminate shock to the pump parts and tubing (Becker Col. 9, lines 65 to Col. 10, line 4). Becker further provides that the cavity (134) with main body (140) is so designed, so that outward movement of each roller piston (152) is limited so that the resultant collapsible tubing (270) is only including a predetermined area, e.g., 180° through 200°. The ramp (63) of the fixed stator (12a) provides Becker's device (5) with an opportunity to have over some minimal radius most adjacent to the inlet and outlet orifice (18) and (20) a greater radium (here 1.844 inches) so that the resilient collapsible tube is only occluded through a predetermined space.

The comparison of interest here is radius of 1.75 inches as compared to 1.844 inches. Clearly, (in Becker) another part of said inner surface is composed of a partial circle of which the center is shifted from the center of said drive shaft, and of which the length of radius is larger or longer then that of said semi circle (See Becker, Col. 11, lines 27-37). For this reason, Becker

does not anticipate or otherwise render obvious new independent claim 13 in which the length of said radium is equal to that of the semi circle.

New independent claim 14 recites a combination of elements in a roller pump including wherein a part of said inner surface of said pump housing is composed of a seamless semi circle, a center of which coincides with the center of said drive shaft, another part of said inner surface is composed of a seamless partial circle.

By contrast, the semi circle of Becker designated by reference numeral 50 is not seamless (See door stator 50 in Fig. 6). This is true even when the semi circle is combined with the other portions of the circular inner circle. Door stator 50 is a key feature of Becker which cannot be modified, and when opened or closed, it provides a seam in the housing. Therefore, the Applicants submit that it is very unlikely that any reference which the Examiner seeks to combine Becker can be so combined without being in conflict with the key purpose of the Becker device. Accordingly, consideration and allowance of independent claim 14 is respectfully requested.

CONCLUSION

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Percy L. Square (Reg. No. 51,084) at the telephone number of the undersigned below, to

conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

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JAK/PLS/te/ags
0044-0251P
Enclosure: Clean copy and marked up copy of Substitute Specification

~~ROLLER PUMP~~
PUMP HOUSING HAVING INTEGRATED REDUCTION GEAR

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention concerns a roller pump that performs pumping action pressing an elastic tube installed in the roller pump with a roller rotation apparatus. Particularly, the present invention concerns an improvement of such a roller pump suitable for medical application.

2. Description of the Prior Art

[0002] In a roller pump of the prior art, a brushless DC motor (for example) is used as a driver that drives the roller pump through a reduction gear with a comparatively large reduction ratio.

[0003] Such reduction gear generally comprises a gear train assembled in a separated independent case.

[0004] A pump housing, the reduction gear and the motor, each manufactured separately, are connected to compose the roller pump.

[0005] An inner surface of the pump housing has a cylindrical form. This cylindrical form is rather complicated. It has a

progressively longer radius in the vicinity of inlet and outlet portions of an elastic tube installed along the inner surface of the pump housing, in comparison with the radius in the vicinity of a central portion of the elastic tube, in order to suppress pulsatory motion of a liquid being transferred from the inlet portion toward the outlet portion of the elastic tube.

[0006] Further, inlet and outlet slots to insert and fix the inlet and the outlet portions of the elastic tube respectively, and to suppress vibration of the elastic tube during operation, are provided with the pump housing. To install the elastic tube into the pump housing, the inlet and the outlet portions of the elastic tube are inserted and fixed in the inlet and the outlet slots of the pump housing respectively.

[0007] In order to make it possible to fix the inlet and the outlet portions of the elastic tube with a different size to the inlet and the outlet slots of the pump housing respectively, such as fixing adapters or levers with springs are used. In the case of the latter, the lever is manually operated to fix each of the inlet and the outlet portions of the elastic tube in the inlet and the outlet slots of the pump housing respectively.

[0008] In the roller pump of the prior art as described above,

there is a problem that the roller pump comprises a large number of parts and it is expensive, since the reduction gear and the pump housing are manufactured separately.

[0009] Also in the roller pump of the prior art in which a brushless DC motor is used as the driver, there is a problem that gears of the reduction gear cause a large noise, the gears wear in a comparatively short period, and a large force is required to manually rotate the rotor when it is necessary, since the brushless DC motor is operated at a comparatively high rotation speed that is reduced to a suitable rotation speed for the rotary pump by a reduction gear with a comparatively large reduction ratio.

[0010] Also in the roller pump of the prior art in which a stepping motor without a rotation sensor is used as the driver, there is a problem that the efficiency is rather low and a large noise is generated, since it is necessary to use a stepping motor with a larger power than the power required for the rotary pump, in order to prevent such stepping motor from stepping out.

[0011] Further, in the roller pump of the prior art, there is a problems that the roller pump is difficult to be manufactured, and therefore it is expensive, since the inner surface of the

pump housing has ~~the~~ a complicated cylindrical form having a progressively longer radius in the vicinity of the inlet and the outlet portions of the elastic tube installed along the inner surface of the pump housing, in comparison with the radius in the vicinity of the central portion of the elastic tube, in order to suppress pulsatory motion of the liquid being transferred from the inlet portion toward the outlet portion of the elastic tube.

[0012] Further, in the roller pump of the prior art in which the fixing adapters corresponding to the size of the elastic tube are used for inserting and fixing the inlet and the outlet portions of the elastic tube to the inlet and the outlet slots of the pump housing respectively, there is a problem that the fixing adapter is often removed together with the elastic tube when only the latter is to be removed.

[0013] Also in the roller pump of the prior art in which the levers with springs are used for fixing the inlet and the outlet portions of the elastic tube to the inlet and the outlet slots of the pump housing respectively, there is a problem that the installing operation of the elastic tube is troublesome, since it is necessary to grasp the elastic tube with one hand and handle the lever with another hand.

SUMMARY OF THE INVENTION

[0014] It is an object of the present invention to provide a roller pump capable of reducing ~~the~~ costs by reducing the number of parts composing the roller pump sharply.

[0015] It is another object of the present invention to provide a roller pump capable of reducing the rotation speed of the drive source, lowering the reduction ratio of the reduction gears, that can be controlled from a low rotation speed to a high rotation speed without stepping out, and of which vibration and noise are low.

[0016] It is a further object of the present invention to provide a roller pump capable of reducing a lashing noise of gears and pulsating motion in the pumping action, at a low cost.

[0017] It is ~~further~~ another object of the present invention to provide a roller pump easy for installing an elastic tube.

[0018] To achieve the above objects, the roller pump according to the present invention comprises a pump housing having a cylindrical inner surface, a rotor fixed to a drive shaft placed at the central portion of the pump housing, rollers provided around the rotor and a driver for driving the

drive shaft through a reduction gear. The rollers press an elastic tube installed between the roller and the inner surface of the pump housing toward the inner surface to transfer a liquid in the elastic tube in a direction, being rotated by the rotor to move the place where the rollers press the elastic tube. The pump housing and the reduction gear are integrated into one body and an output shaft of the reduction gear is fixed to the drive shaft of the rotor.

[0019] By constructing the pump housing and the reduction gear in one body, the number of parts, and consequently the cost, can be sharply reduced.

[0020] Further, to achieve the above objects, a stepping motor provided with a rotation sensor ~~and~~ that is roll controllable is used as the driver.

[0021] By using the stepping motor provided with the rotation sensor, the rotation speed of the driver can be lowered, the reduction ratio can be made smaller, and thus the roller pump is controllable in wide range from a low rotation speed to a high rotation speed, of which vibration and noise are low, can be realized.

[0022] Further, to achieve the above objects, a part of the inner surface of the pump housing is composed of a

semicircle of which center coincides with the center of the drive shaft, another part of the inner surface is composed of a partial circle of which center is shifted from the center of the drive shaft, and of which the length of radius is equal to that of the semicircle. Each of end portions of the semicircle and each of end portions of the partial circle are connected by each of tangential lines extending from each of the end portions of the semicircle toward each of the end portions of the partial circle respectively. The partial circle is made to be a form suitable to be connected to an inlet slot for attaching an inlet portion of the elastic tube, and to an outlet slot for attaching an outlet portion of the elastic tube, respectively.

[0023] Alternatively, a part of the inner surface of the pump housing is composed of a semicircle of which the center coincides with the center of the drive shaft, another part of the inner surface is composed of a partial circle of which center is shifted from the center of the drive shaft, and ~~6f~~ of which the length of the radius is larger than that of the semicircle. Each of end portions of the semicircle and each of end portions of the partial circle are connected respectively. The partial circle is made to be a form suitable to be connected to an inlet slot for attaching an inlet portion of the

elastic tube, and to an outlet slot for attaching an outlet portion of the elastic tube, respectively.

[0024] By making the inner surface of the pump housing in the forms as described above, the roller pump capable of reducing the beating sound of gears as well as the pulsation in pumping action can be provided at a low cost.

[0025] Further, to achieve the above objects, the inlet slot is provided with a lever for pressing the inlet portion into the inlet slot to hold the inlet portion in the inlet slot. The lever is rotated perpendicularly to the axis of the elastic tube by a spring force to press the inlet portion of the elastic tube, and an upper end portion of the lever is tilted relative to the vertical axis. The inlet portion is attached to the pump housing being pushed downward through a place between the upper end portion and the inlet slot. Also, the outlet slot is provided with a lever for pressing the outlet portion into the outlet slot to hold the outlet portion in the outlet slot. The lever is rotated perpendicularly to the axis of the elastic tube by a spring force to press the outlet portion of the elastic tube, an upper end portion of the lever is tilted relative to the vertical axis. The outlet portion is attached to the pump housing being pushed downward through a place between the

upper end portion and the outlet slot.

[0026] By providing such levers to the inlet and outlet slots, installing of the elastic tube can be made easily.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Fig. 1 is a longitudinal sectional view showing the principal part of the roller pump according to the present invention.

[0028] Fig. 2 is a horizontal sectional view along A-A line in Fig. 1.

[0029] Fig. 3 is a sectional side elevation along B-B line in Fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Preferred embodiments of the roller pump according to the present invention ~~is~~ are explained referring to the attached drawings.

[0031] Fig. 1 is a longitudinal sectional view showing the principal part of the roller pump according to the present invention.

[0032] Fig. 2 is a horizontal sectional view along A-A line in Fig. 1.

[0033] Fig. 3 is a sectional side elevation along B-B line in Fig. 2.

[0034] In Figs. 1 and 2, 1 is a pump housing, 2 is a cover of the pump housing 1, 3 is an inner surface of the pump housing 1, 4 is a rotor, 5 is a rotor shaft that is a drive shaft of the rotor 4, 6 is a roller, 7 is a roller shaft, 8 is a bearing, 9 is a reduction gear, 10 is an elastic tube, 11 is an inlet slot, 12 is an outlet slot, 13:13' are levers for holding the elastic tube 10, 14,14' are shafts of the levers 13,13' respectively, 15,15' are springs for applying rotational forces to the levers 13, 13' respectively, 20 is a stepping motor, 21 is a rotation sensor for the stepping motor 20 and 22 is a drive control circuit of the stepping motor 20.

[0035] Construction of the rotor 4 is now explained in detail referring to Figs. 1 and 2.

[0036] The central portion of the rotor 4 is fixed to the rotor shaft 5. The rotor 4 comprises two roller supporting plates 4-1 of a triangular shape, each placed at a symmetrical position with regard to the rotor shaft 5. A side end of the roller supporting plate 4-1 is rotatably attached to the rotor

4 with one of support shafts 4-2 parallel with each other. Another side end of the roller supporting plate 4-1 is provided with a spring 4-3 that pushes the roller supporting plate 4-1 outwardly to rotate it around the support shaft 4-2. The roller 6 is rotatably attached to the each external end portion of the roller supporting plate 4-1 with the roller shaft 7 parallel to the rotor shaft 5. A periphery of the roller 6 is partially protruding out of the roller supporting plate 4-1. The roller 6 is pressed outwardly by the spring 4-3 through the roller supporting plate 4-1 and presses the elastic tube 10 installed between the inner surface 3 of the pump housing I and the rotor 4.

[0037] As shown In Fig. 1, two bearings 8 for supporting the rotor shaft 5 are provided in the lower part of the pump housing 1. The rotor 4 is fixed to an upper end portion of the rotor shaft 5. The reduction gear 9 is installed under the rotor shaft 5. The stepping motor 20 is installed under the reduction gear 9. A lower end portion of the rotor shaft 5 is connected to the stepping motor 20 through the reduction gear 9. Driving force of the stepping motor 20 is transmitted to the rotor shaft 5 through the reduction gear 9.

[0038] The rotation sensor 21 is provided with the stepping

motor 20.

[0039] As shown in Figs. 1 and 2, the inner surface 3 of the pump housing 1 is formed in a cylindrical form and has a height capable of receiving the rotor 4 in it. The inlet slot 11 and the outlet slot 12 for holding an inlet portion and an outlet portion of the elastic tube 10 respectively are provided at a side end portion of the pump housing 1. The elastic tube 10 is installed in the pump housing 1 along the inner surface 3 in a U-shape with the inlet portion and the outlet portion held in the inlet slot 11 and in the outlet slot 12 respectively.

[0040] Referring to Fig. 2, a horizontal section of the right portion (the portion where the inlet slot 11 and the outlet slot 12 are not formed) of the inner surface 3 of the pump housing 1 is composed of a semicircle 3-1 having a radius r, the center of which coincides with the center of the rotor shaft 5. A horizontal section of the left portion (the portion where the inlet slot 11 and the outlet slot 12 are formed) of the inner surface 3 of the pump housing 1 is composed of a partial circle 3-3 having also a radius r, the center of which is ~~sifted~~ shifted to the left of the center of the rotor shaft 5. Each end of the semicircle 3-1 and each end of the partial circle 3-3 are connected by each tangential line of the semicircle 3-1

extending from each end of the semicircle 3-1 toward each end of the partial circle 3-3, respectively. In other words, the horizontal section of the inner surface 3 presents an ellipse-like form made of the semicircle 3-1 and the partial circle 3·3 having the same radius r, the centers of which are shifted with each other, and the each end of which is connected with each other by each tangential line 3-2. Additionally, the left portion of the partial circle 3·3 are formed into an appropriate form to be connected to the inlet slot 11 and the outlet slot 12.

[0041] The elastic tube 10 is pressed by the two rollers 6 toward the inner surface 3 of the pump housing 1 thus formed. Accordingly, the inner side of the elastic tube 10 presents a form shown by a two-dot chain line in Fig. 2. As the upper roller 6 in Fig. 2 moves toward the left, the roller 6 that has been opposing to the tangential line 3-2 of the inner surface 3 of the pump housing 1 ~~be~~comes to oppose the partial circle 3-3. Since the center of the partial circle 3-3 is shifted to the left by the length of the tangential line 3-2, the distance between the inner surface 3 of the pump housing 1 and the roller 6 becomes longer, and the pushing force of the roller 6 against the elastic tube 10 becomes weaker. As the

pushing force of the roller 6 against the elastic tube 10 becomes weaker, a repellent force in the rotating direction applied to the roller 6 by the elastic tube 10 at the time when the roller 6 departs from the elastic tube 10 also becomes weaker. Accordingly, the noise generated in the reduction gear 9 can be reduced.

[0042] At the time when the lower roller 6 in Fig. 2 begins to contact the elastic tube 10, the roller 6 contacts the portion of the elastic tube 10 in the partial circle 3-3. As the rotor 4 rotates counter-clockwise, the distance between the roller 6 and the inner surface 3 of the pump housing 1 becomes gradually shorter, then the distance becomes minimum at the point of contact of the tangential line 3-2 with the semicircle 3-1. After that, the distance remains constant during 180 degrees rotation of the rotor 4. Accordingly, the torque required for rotating the rotor 4 gradually increases, then becomes the maximum and remains constant during 180 degrees rotation of the rotor 4. Consequently, the variable component of the force applied to the gears of the reduction gear 9 as well as to the stepping motor 20 is small, the noise generated is low, and the life of the gears of the reduction gear 9 can be lengthened.

[0043] In place of the form of the inner surface 3 as described above another form of the inner surface 3 in which another partial circle 3-3 having a radius slightly longer than that of the semicircle 3-1, and the center of which is ~~sifted~~ shifted to the left of the center of the rotor shaft 5, is used to connect the each end of the semicircle 3-1 with the inlet slot 11 or the outlet slot 12 respectively.

[0044] Also in this form of the inner surface 3, the distance between the roller 6 and the inner surface 3 increases gradually as the roller 6 moves from the end portion of the semicircle 3-1 toward the outlet portion of the elastic tube 10 and decreases gradually as the roller 6 moves from the inlet portion of the elastic tube 10 toward the end portion of the semicircle 3-1. Consequently, the noise generated by the reduction gear 9 can be reduced and the life of the gears of the reduction gear 9 can be lengthened, similarly to the embodiment described above.

[0045] A form of the outlet slot 12 is shown in Fig. 3. As shown in the drawing, an upper portion 12-1 and a lower portion 12-3 of the outlet slot 12 are formed to be comparatively wide in width, whereas a mid portion 12-2 of the outlet slot 12 is formed to be comparatively narrow in

width. Thus formed outlet slot 12 enables an easy insertion, as well as prevention from falling-off, of the outlet portion of the elastic tube 10 having an external diameter of various size. Additionally, the inlet slot 11 is also formed similarly to the outlet slot 12, which also has the same effects as those of the outlet slot 12.

[0046] As shown in Figs. 2 and 3, a lever 13 for pressing and holding the inlet portion of the elastic tube 10 is provided to the out side of the inlet slot 11. Similarly, a lever 13' for pressing and holding the outlet portion of the elastic tube 10 is provided to the out side of the outlet slot 12. The lever 13 is rotatably attached to the inlet slot 11 with a shaft 14 parallel to the inlet slot 11. Similarly, the lever 13' is attached to the outlet slot 12 with a shaft 14' parallel to the outlet slot 12. The lever 13 is provided with a spring 15 that makes the lever 13 press the inlet portion of the elastic tube 10 in the inlet slot 11, toward the inner portion of the inlet slot 11. Also, the lever 13' is provided with a spring 15 that makes the lever 13' press the outlet portion of the elastic tube 10 in the outlet slot 12, toward the inner portion of the outlet slot 12. Thus, the inlet portion of the elastic tube 10 is pressed toward the inlet slot 11 and is held there. Also, the

outlet portion of the elastic tube 10 is pressed toward the outlet slot 12 and is held there.

[0047] As shown in Fig. 3, upper end portions 13-1,13'-1 of the levers 13 are tilted relative to the vertical axis and form a part of V-shape. The inlet portion of the elastic tube 10 is pushed into a place between the mid portion (not shown in the drawing) of the inlet slot 11 and the upper end portion 13-1 of the lever 13, then the tilted upper end portion 13-1 is rotated toward the right opposing to the spring force of the spring 15 and allows the inlet portion of the elastic tube 10 to pass through into the inlet slot 11. Similarly, the outlet portion of the elastic tube 10 is pushed into a place between the mid portion 12-2 of the outlet slot 12 and the upper end portion 13'-1 of the lever 13', then the tilted upper end portion 13'-1 is rotated toward the left opposing to the spring force of the spring 15 and allows the outlet portion of the elastic tube 10 passing through into the outlet slot 12. As inlet portion and the outlet portion enter into the inlet slot 11 or outlet slot 12 respectively, they are pressed into the inlet slot 11 or outlet slot 12 respectively, and the elastic tube 10 is prevented from falling-off.

[0048] Such operation of attaching the inlet and outlet

portions of the elastic tube 10 to the inlet slot 11 or outlet slot 12 can be handled by one hand in one action. Comparing with the roller pump of the prior art in which such operation needs to be handled by two hands, the roller pump according to the present invention is easier to be handled.

[0049] To install the elastic tube 10 of the roller pump according to the present invention, a cover 2 (see Fig.1) rotatably attached to the pump housing 1 is opened, then the inlet portion of the elastic tube 10 is fixed to the inlet slot 11 of the pump housing 1 in the manner as explained above, and then the elastic tube 10 is laid in the pump housing 1 in a U-shape, passing through the place between the roller 6 and the inner surface 3 of the pump housing 1. Then, the outlet portion of the elastic tube 10 is fixed to the outlet slot 12 of the pump housing 1, also in the manner as explained above, and then the cover 2 is closed.

[0050] The roller pump according to the present invention is operated as follows. First, a pulse current of a predetermined pulse number is transmitted from the drive control circuit 22 into the stepping motor 20. Upon receiving the pulse current, the stepping motor 20 starts to rotate. The rotation of the stepping motor 20 is transmitted to the rotor 4 through the

reduction gear 9. As the rotor 4 rotates, two rollers 6 attached to the rotor 4 rotate pressing the elastic tube 10, by a spring force of the spring 4-3, toward the inner surface 3 of the pump housing 1. As the elastic tube 10 is pressed toward the inner surface 3 of the pump housing 1, the elastic tube 10 is blocked. The place in the elastic tube 10 being blocked is moved with the movement of the rotor 4. Consequently, the liquid in the elastic tube is transferred toward the outlet. Thus, the roller pump carries out the pumping action.

[0051] In the embodiment of the roller pump according to the present invention as explained above, the stepping motor 20 with the rotation sensor 22 is used. A stepping motor has a number of magnetic teeth both in a rotor and in a stator and the rotation speed of the stepping motor is controlled by a pulse number of a pulse current applied to the stator. Consequently, the controllable range of the rotation speed is wider than that of a brushless DC motor. Since the stepping motor 20 is used in the roller pump according to the present invention, the controllable range of the amount of the liquid to be transferred by the roller pump can be made wider. Particularly, the operation of the roller pump at low speed is stable.

[0052] Further, since the reduction ratio of the reduction gear can be made smaller, a reduction gear of a small size can be easily integrated in the pump housing. Further, since the rotor 4 can be rotated by hand with a small force, the roller pump can be easily handled in such an operation as installing the elastic tube 10 into the pump housing 1 in which it is necessary to rotate the rotor 4 by hand.

[0053] Additionally, a reduction gear comprising planetary gears or other gears can be used.